New constraints on mantle evolution from combined La-Ce, Sm-Nd and Lu-Hf isotope systematics

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In combination, La-Ce, Sm-Nd, and Lu-Hf isotope systematics in oceanic basalts provide crucial information about the time-integrated light rare earth element (REE) evolution of their mantle sources. Continuous magmatic differentiation by partial melting and recycling of oceanic and continental crust produces variably light REE depleted mantle with a range of light REE enriched recycled materials.

On a global scale, this evolution is manifest in arrays with a negative slope in Ce-(Nd-Hf), and positive slope in Nd-Hf isotope space. The slope and extent of the Ce-(Nd-Hf) and Nd-Hf arrays are sensitive to the rates of partial mantle melting and crustal recycling, as well as the variable proportions of different components available for sampling on a regional and global scale.

The Ce-(Nd-Hf) arrays imply that recycled continental crust is an important part of *most* ocean island (OIB) and mid ocean ridge basalt (MORB) sources, not just typical EM OIB sources. The extent and slope of the Ce-(Nd-Hf) arrays are sensitive to the type of recycled continental crust, in contrast to the Nd-Hf array. Ce-Nd-Hf isotope ratios in oceanic basalts therefore allow distinguishing between the type of recycled continental material included in their mantle sources.

Ce-Nd-Hf isotope ratios in oceanic basalts are highly sensitive to the variable presence of depleted mantle. On a global scale, the slope and extent of the Ce-(Nd-Hf) isotope mantle arrays constrain the extent and age of depletion of the depleted mantle involved in MORB and OIB sources, indicating that the lifetime of depleted material is generally < 2 Ga. On a more regional scale of individual MORB-OIB localities, the presence and nature of depleted mantle involved has great leverage on the slope and width of the individual Ce-(Nd-Hf) isotope arrays, even for the most enriched EM OIB sources.

High-precision Ce isotope ratios in MORB and OIB therefore provide additional constrains on the nature of both enriched and depleted mantle sources that are not available from conventional lithophile isotope ratios (Sr-Nd-Hf-Pb).